Installed Inspection Sensors and Cloud-based Software for Continuous Monitoring and Advanced Analytics
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Abstract

The use of sensor technology for continuous monitoring of corrosion on critical assets is increasing. Ultrasonic sensors and cloud-based software applications can allow operators to manage and decrease risk, while proactively make disposition decisions and minimizing total cost of operations. The energy industry utilizes less than 5% of all collected data. New technologies that provide a method to gather and harness such data can improve the reliability of inspections, remove manual inconsistencies, and enable users to predict failures due to corrosion and thus extend asset life.

Introduction

Corrosion management is one of the top asset management focus areas for oil and gas companies. Production and processing facilities face corrosion-related threats, including impurities in crude oil, chemicals used in processing, and process conditions like pressure and temperature. Failure to pro-actively monitor assets and act within the opportunity window can lead to severe financial, safety, and regulatory issues.

With declining crude quality and the high profit potential of opportunity crudes, refiners now face a difficult balancing act: determining the optimum combination of crude blends, unit operations, corrosion control programs and unit maintenance to achieve the greatest ROI.

In the overhead of refineries’ crude atmospheric distillation unit, corrosion has become a challenge as conventional light, sweet crude stocks have been replaced with heavy, sour, acidic crudes and amine-contaminated tight oils. While these crudes entice refiners with hopes of improved processing margins, they bring with them various amines and increased chloride levels that increase the risk of salt corrosion.

Salt-induced corrosion poses the most common and costly challenge and can result in failing overhead condenser bundles that may need to be replaced in as little as 6-24 months. Shutting down the crude unit for weeks or months to repair corrosion damage hinders both the operability and profitability of the entire refinery.

Traditional inspections and conventional corrosion control programs

Organizations continue to rely on manual inspection methods and conventional corrosion control programs. However, manual inspections are time consuming, and data quality and consistency are a constant challenge. Data is then analyzed for critical indicators in siloed applications. Field technicians often must perform follow-ups due to data inconsistencies or seek expert guidance for complex processes. Similarly, conventional corrosion control programs rely on estimations and approximations to determine a filming inhibitor and neutralizing amine strategy, but this approach often falls short.
A new approach to predicting and managing corrosion

Digital inspections armed with ultrasonic sensors, cloud computing, and analytics enable an improved and proactive approach to corrosion management. The installed sensors stream interior wall thickness and temperature readings into a cloud-based repository, which provides high computing power, scalability, centralized storage, and analytics capability. Facilities benefit from more reliable data and trending to assist in the detection and diagnosis of failures due to corrosion. The ability to correlate process data with thickness data helps enhance operational awareness, delivers actionable insights to key stakeholders effectively and efficiently, and improves decision making.

Figure 1: Hardware schematic for BHGE’s Predictive Corrosion Management (PCM) Rigtrax PM installed sensing technology
Real-time corrosion risk assessment using the Ionic Model

The BHGE Ionic Model is a comprehensive and robust simulation technology that provides critical insight into the phase behavior that leads to corrosion. Built on a foundation of thermodynamic data for amine behavior and reactivity with hydrochloric acid (HCl), the technology has been shown, in refinery practice, to provide an accurate assessment of risk, screening of options to mitigate corrosion and monitoring to provide advance warning of the onset of corrosion. By providing information about the probability, location, and severity of corrosion problems in the system, the simulator guides the refiner’s decision to the most effective and economical combination of chemical treatments and changes to operating conditions to arrive at the best mitigation solution.

Using the Ionic Model, the shortcomings of conventional corrosion control programs are avoided, and engineers can:

- Detect the risk of corrosion from any of the commonly encountered amine salts in the crude unit, including neutralizer salts, contaminant amine salts, ammonia salts, and boiler amines.
- Use the field data to predict how changes to flow rates, crude blend composition, and other operating conditions impact corrosion.
- Define the optimal operating envelope to keep salt formation to a minimum and do so with an unprecedented level of accuracy.
- Recommend changes in process conditions and the optimal time to inject inhibitors to maintain optimum product mix and profitability while maintaining the mechanical integrity of the asset.

The Ionic Model contains proprietary thermodynamic data for amines and their reaction with HCl to produce corrosive salts. The phase diagram in Figure 3 is an example of the thermodynamic relationships.
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The Ionic Model calculations are imbedded into BHGE’s Corrosion Risk Monitor, a software tool that provides a graphical indication of corrosion risk along with calculated salt formation temperature data. An example of the output for a double drum overhead system is shown in Figure 4.

Figure 3: Example of thermodynamic phase diagram for amine/HCl system

Figure 4: Corrosion risk assessment for two-drum overhead system
In one example, mean time between overhead bundle failures had declined from 5+ years to as short as 5 months. Under-salt corrosion was the diagnosis, and a change in neutralizer product combined with a target maximum for overhead chloride concentration was prescribed. Bundle life increased significantly with the new operating window in place. In another example, multiple factors were influencing overhead system corrosion risk, causing a combination of ammonium chloride salt corrosion in overhead line deadlegs, sulfur attack on copper/nickel exchanger tubes, and velocity accelerated corrosion in exchanger outlet bend piping. The Ionic Model was used to successfully diagnose all three corrosion risks and provided mitigation strategies to manage the risk. In yet another example, the top trays of the crude distillation tower were severely corroded by hydrochloride salts of mono-ethanolamine (MEA). Analysis using the Ionic Model led to a successful control strategy, an example of which is depicted in Figure 5, featuring a target for caustic injection to reduce overhead chloride (from 14 ppm to 5 ppm) combined with an amine removal treatment to reduce MEA concentration (from 15 ppm to 4 ppm).

The combination of these moves enabled the refiner to maintain tray and tower integrity during the next run cycle, avoiding lost production due to corrosion causing loss of distillation control. The tray condition following a 2-year run without mitigation and tray condition following a 2-year run with mitigation are shown in Figure 6.
Furthermore, the advent of increasingly capable online instrumentation has enabled refiners to measure contaminants on an hourly basis that were previously only run by hand every few days. By increasing the frequency of data capture and integrating cloud computing and data analytics, the Ionic Model will deliver near real-time feedback on overhead corrosion risks directly to a refiner’s data historian or DCS.

Figure 6: Tray conditions with and without mitigation

Figure 7: Online overhead system analyzer
By placing the critical Ionic Model outputs in front of the eyes of operators, engineers, and managers, the refiners gain the confidence to respond immediately to changing crude characteristics such as amine or salt loading. In the case of increasing risk, the refiner might implement a predetermined mitigation strategy to remain within the desired integrity operating window: increase the overhead temperature or start up their desalter acidification program. For the decreasing risk scenario, the refiner is able to reduce the overhead temperature and maximize the yield benefits of increased distillate production. Combining the Ionic Model capability with digital inspection technology and cloud-based data analytics raises asset reliability to a new plateau.

Enhancing a mechanical integrity program

Mechanical Integrity is a key part of a successful Asset Performance Management program and essential to ensuring safety and compliance. A solid Mechanical Integrity strategy accounts for asset criticality, failure modes, damage mechanisms, and other factors to evaluate risk and craft appropriate mitigation strategies. Once a Mechanical Integrity strategy is defined, it can be optimized by complementing it with sensors to obtain real-time information about the status of assets. Additionally, utilizing sensors in combination with advanced predictive techniques plus a strategic chemical inhibitor program and ionic analytical model can give refiners an increased level of confidence as to the risk status of their assets.

Figure 8: Reducing risk and enhancing mechanical integrity
Driving better outcomes and value

Processing challenges are likely to continue as refiners attempt to maximize the profit potential promised by the growing volumes of unconventional feedstocks. This potential can only be realized through digital inspections in combination with a suite of mitigation strategies that are informed by monitoring, modelling, and thermodynamic simulation (Ionic Model) capable of identifying the root cause of corrosion.

Digital inspections enable data collection of interior pipe wall thickness and temperature, detection and visualization of wall loss due to corrosion, and an increase in asset integrity and decrease in downtime. When implemented in combination with the Ionic Model, they can help refineries to define the optimum operating envelope for increased feedstock flexibility, respond to changing unit conditions for improved process reliability, increase capacity utilization for increased profitability, and reduce maintenance cost by extending equipment life.

Conclusion

Refinery corrosion remains one of the most-costly factors in refinery operating and maintenance budgets. Corrosion risks are on the rise as crude oil sources become heavier and contain more contaminants. The traditional corrosion inhibitor treatment by itself is insufficient to manage the growing risks properly. A combination of advanced technologies is now required to understand the underlying factors leading to corrosion, to define a cost-effective mitigation approach, and to monitor and ensure asset integrity and reliability. Cloud-based analytics and models, enhanced thermodynamic simulations and digital inspection capabilities are just a few of the technologies available today to help refiners achieve their operating goals and maximize profitability of their operations. As crude oils throw new challenges at the refiner, new tools and capabilities are available to address those challenges.
References


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